

BWM
Nov. 2004
Effective Date
1-1-05

LUCAS COUNTY ENGINEERS OFFICE
STORM DRAINAGE DESIGN

Drainage

The design of storm sewer systems will be based upon the "Rational Method" using the equation $Q=CiA$ and the "Manning Formula" (A is less than 100 acres). Areas greater than 100 acres use State of Ohio Bulletin Number 43 and compare with Bulletin Number 45 Floods in Ohio or Soil Conservation Service Technical Release #55, 2nd edition.

- A. The rainfall intensity, "I", will be taken from the appropriate curve for the Toledo, Ohio, area as published in Technical Paper No. 25, of the U.S. Weather Bureau. "Rainfall Intensity-Duration-Frequency Curves for Selected Station in the United States, Alaska, Hawaiian Islands and Puerto Rico" Government Printing Office, 1955.
- B. A minimum of $t=20$ minutes may be used as the time of concentration to the first pick-up point in the system, in residential areas. In areas other than residential, time of concentration shall be determined by the use of overland flow charts.
- C. The runoff coefficients for rational method shall be used as shown on page 6. When a soil has two hydrologic groups the sandier soil grouping can be used for determining the proposed runoff coefficient. Example: B/D Hydrologic group proposed residential subdivision with average 1/3 acre lot size "C"=0.32.
- D. Storm sewers shall be designed to flow just full for the 5 year intensity-duration-frequency curve. The minimum velocity at just full shall be 2 feet per second. Minimum pavement gutter elevations shall be at or above the hydraulic grade line for a 10 year frequency storm. Use the 10 year intensity-duration-frequency curve for determining this hydraulic grade line. Main line storm sewers should not be placed in rear yards.
- E. Catch basin type and spacing shall be designed using the 2 year intensity-duration-frequency curve. The maximum allowable width of the sheet gutter flow from the face of the curb shall be limited to 8 feet into the driving lane. Curb inlets will usually be required at all intersections and cul de sacs to provide for more positive drainage.
- F. An overall drainage area layout showing the limits of the contributing runoff area, broken down into areas contributing to each drainage pick-up point, shall be submitted prior to the development of final paving and drainage plans. Drainage design within the development shall be adequate to handle the entire contributing watershed area, and its existing, proposed and probable future development, and not the area under submission only. When the design makes use of an existing storm sewer or open ditch, cross sections and profiles shall be submitted which show the existing conditions at least 500 feet downstream from the plat being considered. The outletting stream for the development may need to be improved

before development begins. An approved plan and County inspection is required when cleaning any ditch required for plat approval. If future plat extensions will utilize the same drainage system, the overall drainage plan shall be submitted with the first plat paving plans.

- G. Complete drainage calculations shall be submitted for pipe size determinations, 10 year hydraulic gradient checks and catch basin type and spacing designs. All culverts will be designed for a 10 year frequency storm with a hydraulic gradient check for a 25 year storm. The County has data for many ditches with 10 year hydraulic grade lines already determined. No twin culverts will be allowed. See FEMA section Y.
- H. Storm sewers and culverts shall be designed to conform to the requirements of Item 603 of the current State of Ohio, Department of Transportation Construction and Material Specifications. Pipe under pavement shall be Type "A" or "B" Conduit. Pipe not under pavement shall be Type "C" Conduit. The designer may indicate a particular kind of pipe by inserting the specification item number after the designation of the type of conduit. Pipe permitted are:

Item 603, Conduit, As Per Plan

Where Type B or C Conduit of less than or equal to 18" diameter is specified the contractor may use any of the following conduit materials:

Concrete Conduit:

*ODOT 706.02 with 706.11 joints

The bedding for Type C Conduit may consist of a natural foundation with recesses shaped to receive the bell and spigot pipe. Scarify and loosen the middle one third of the trench.

Polyvinyl Chloride (PVC) Conduit:

*ODOT 707.42

*ODOT 707.43

*ODOT 707.45 (For 15" and under diameter)

*ASTM F679 (For 18" diameter)

PVC Conduit will only be permitted at those locations where a minimum cover from the top of the pipe to the bottom of the subgrade is 12 inches, however, for no installation shall the distance from the top of the pipe to the surface of pavement, or finish grade for conduit not under the pavement, be less than 18 inches. The bedding shall extend to a height of 12 inches above the top of the polyvinyl chloride conduit.

Polyethylene Conduit:

*ODOT 707.33 with in-line bell couplings and o-ring rubber gaskets meeting ASTM F477 only.

Polyethylene conduit will only be permitted at those locations where a minimum cover from the finish grade to the top of the pipe is 18 inches or greater. The bedding shall extend to a height of 12 inches above the top of the polyethylene conduit.

Where 21” or 24” diameter is specified for either Type B conduit not under the mainline pavement including shoulder and berm, or Type C conduit. The contractor may use any of the following conduit material:

Concrete Conduit

*ODOT 706.02 with 706.11 joints

The bedding for Type C conduit may consist of a natural foundation with recesses shaped to receive the bell and spigot pipe. Scarify and loosen the middle one third of the trench.

Polyvinyl Chloride (PVC) Conduit:

*ODOT 707.42

*ODOT 707.43

*ASTM F679

PVC Conduit will only be permitted at those locations where a minimum cover from the finish grade to the top of the pipe is 18 inches or greater. The bedding shall extend to a height of 12 inches above the top of the PVC conduit.

Polyethylene Conduit:

*ODOT 707.33 with in-line bell couplings and o-ring rubber gaskets meeting ASTM F477 only.

Polyethylene conduit will only be permitted at those locations where a minimum cover from the finish grade to the top of the pipe is 18 inches or greater. The bedding shall extend to a height of 12 inches above the top of the polyethylene conduit.

For 21” & 24” Type B Conduit under mainline pavement including shoulder and berm, and for 27” Conduit and over the Contractor shall use:

Concrete Conduit:

*ODOT 706.02 with 706.11 joints

The bedding for Type C conduit may consist of a natural foundation with recesses shaped to receive the bell and spigot pipe. Scarify and loosen the middle one third of the trench.

It is the designers responsibility to determine which conduit meets as per plan bidding conditions, and which conduit is closed to a specific conduit type. The plan’s subsummaries and general summaries shall reflect this. Corrugated metal pipe will be permitted only when being used as a restriction in a detention facility. The design manning roughness coefficient for corrugated pipe shall be .024. All other pipe shall have a design coefficient of .013.

Type "A" and "B" Conduit shall have a minimum cover of 9" from the top outside crown to the bottom of the finished subgrade for concrete pipe and 12" minimum cover for polyvinyl chloride and polyethylene conduit. Type "C" Conduit with less than 18" of cover shall be reinforced concrete. Pipe shall be minimum 12" diameter beyond the first structure which picks up surface water.

- I. Mainline storm sewers should not be placed in rear yards. 12" crossovers shall have a 1% grade for better cleanout purposes.
- J. Grading plans will be required showing the proposed elevations at the right of way line, building lines and back lot lines. In areas where the site grading plan calls for the conveyance of surface storm water along or across rear property lines, a catch basin shall be provided to limit the length draining to the basin to a maximum of the lesser of 3 lots or 300 feet in any one direction. For the sump condition with back to back lots, a maximum of 12 lots may drain to one catch basin. A desirable grade of 0.5 and an absolute minimum grade of 0.3% shall be provided for rear lot swales.
- K. Rock channel protection will be required at all sewer and culvert outlets.
- L. Storm sewer taps shall be provided for all lots unless basements and crawl spaces are prohibited by plat recitation. Taps shall be outletted to the main storm sewer system for the development and may not be outletted directly to open ditches or rear yard drainage. Storm sewer taps shall be a minimum of 6" diameter and shall be carried to the right of way line or on to the lot. If more than one lot is served by a single line, the line shall be sized assuming each lot is contributing 50 gal./min (0.11 c.f.s.). The minimum velocity for full flow shall be 2 ft./sec. In structures storm sewer taps shall be placed at least 6 inches above main line sewers and into structures whenever possible.
- M. Any storm sewers connecting into State of Ohio drainage systems or crossing state highways must be approved by the Ohio Department of Transportation.
- N. For manhole and catch basin locations, use the center of the structure.
- O. Cross sections shall show all cross overs, catch basins and manholes.
- P. Detention facilities will be required by the County and the allowable flow out will be limited to the existing 5 year intensity storm for existing conditions of the proposal site. The detention facility shall store the proposed flow from a 25 year intensity storm. Existing conditions may limit the allowable out flow of the proposed site. For example, a proposed development may drain 20 acres to a ditch or conduit that receives a total drainage area of 100 acres. The existing ditch or conduit may have the capacity to carry 20 c.f.s. and it was determined that the existing conditions for the 20 acres to be developed carried 20 c.f.s. In this situation, the proposed site would be prorated over the entire drainage area and would be allowed one fifth of the outlet capacity (4 c.f.s.) since the site has one fifth of the overall drainage area. The storage area for the detention pond should be above the 10 year storm of the outletting stream. The outlet conduit for the detention area must be set above normal water elevation of the receiving stream, ditch, or conduit. Detention ponds will be

maintained by owners and County will put residential subdivision detention ponds under a petition to be maintained by County as a backup only. When determining meter size for detention ponds Q flow and not Q avg. shall be used for determining peak discharge. Detention ponds should be set up near outlet on separate lot and not in rear yards. See sample storm water detention calculations sheets 7, 8, and 9.

- Q. Maximum spacing between access structures (catch basins or manholes) shall be 350 feet for pipe sizes of 36" and under and 500 feet for sizes over 36".
- R. All catch basins and manholes shall be constructed without sumps or traps, except where two main runs intersect then a sump would be required. Also a sump is required at the last manhole prior to the outlet.
- S. Access to main line storm sewers shall be provided through the use of manholes located to keep the sewer a sufficient distance behind the edge of pavement or curb line. Catch basins are not to be located on the main line storm sewer, on curbed or urban pavement typicals, but is allowed on rural typicals.
- T. Rear yard catch basins shall be constructed and rear yard swales graded at the time the development's storm drainage and pavement is constructed. Swales shall be seeded, mulched and fertilized. Silt fences shall be placed around all rear yard catch basins.
- U. Subdivisions which are involved with an open ditch may be required to enclose the ditch if the enclosure would involve a 48 inch conduit or smaller size. Larger open ditches may require that side slopes of ditch banks be stabilized with dumped rock or by some other means. Ditch easements will be required for ditches from top of bank plus 20 ft. on one continuous side. No dual culvert systems will be allowed. Enclosure must be single structures. See FEMA section Y.
- V. Drive entrances may disturb County, State, or Township Right of Way and may require drive tiles, and a permit.
- W. Storm sewer easements shall be a minimum of 20 feet for all storm sewers and a minimum 15 feet for drainage easements involving swales.
- X. Requirements for NPDES permits shall be followed when permit is required.
- Y. FEMA regulations shall be strictly followed for all developments. Impacts on floodway and floodway fringe shall be addressed. Filling in floodplain requires permit from Lucas County Building Regulations. Flood boundaries shall be shown on plans along with 100 year storm elevations. All necessary CLOMRs, LOMRs, or LOMAs shall be secured from FEMA before construction of buildings can commence. FEMA studied streams and ditches require that new structures do not raise 100 year storm elevation unless public notification is performed and all parties affected by change are contacted and are agreeable to the raise in the 100 year storm elevation.

RUNOFF COEFFICIENTS FOR RATIONAL METHOD

LAND USE DESCRIPTION	HYDROLOGIC SOIL GROUP			
	A	B	C	D
Cultivated Land: without conservation treatment 				

The coefficients are applicable for storm of five to ten year return frequencies.

For recurrence intervals longer than ten years, the indicated runoff coefficients should be increased, assuming that nearly all of the rainfall will become runoff and should be accommodated by and increased runoff coefficient.

Source: Medina County Stormwater Management & Sediment Control Rules and Regulations, Dec. 1998, Page 53

Date.....Subject: Storm Water Detention Sheet No. 1 of 3
 Chkd. By.....Date.....Calculation.....Job No.....

1. Gross Area = _____ S.F.
 2. Pavement Area = _____ S.F.
 3. Building Area = _____ S.F.
 4. Total Impervious _____ S.F. = _____ S.F. x 0.90 = _____
 5. Net Pervious Area = _____ S.F. x 0.15 = _____
 6. Wt. C. = $C_w = \frac{C A_I}{A_T} = \frac{C \times A_I}{A_T} +$ _____
 7. Allowable Q into exist system (see Design Considerations "Sect. IV-N") ~~100' storm pipe~~
 (April, 1977) ~~in or~~
~~nearest end~~

Old Method $\rightarrow Q_{allow} = C_i A = 0.15 \times 3.2 \times A_T / 43560 = 0.15 \times 3.2 \times \overline{43560} =$
 See Example
 Lucas County \rightarrow (Note: $i_5 = 3.2"/hr.$ (5 year 20 min.)

Detention Volume Required

tc min)	i_{25} in/hr	$C_w A$ (A=Acres)	Q_{in} Q_{25}	$Q_{out} =$ Q_{allow}	$Q_{in} - Q_{out}$	$(Q_{in} - Q_{out}) \times t_c \times 60$ ft ³	Design Detention Volume
20	4.40						
30	3.60						
40	3.00						
50	2.60						
60	2.30						
70	2.10						
80	1.90						
90	1.70						
100	1.60						
110	1.50						
120	1.40						
130	1.30						
140	1.20						
150	1.15						
160	1.10						
170	1.05						
180	1.00						

If peak storage volume is not reached within the 3 hr. time period in the above table, continue this procedure until peak storage volume is reached. Rainfall Intensity Chart, dated 4/17/61, is available from this office upon request.

Determination of Design Detention Volume

Area	End Area of Section	Length	Volume (ft ³)

0. Detention Design Meter Line Check (Culvert Analysis)

$$H = \frac{V^2}{2g} \left(1 + K_e + \frac{29n^2L}{R^{4/3}} \right)$$

$$2gH = V^2 \left(1 + K_e + \frac{29n^2L}{R^{4/3}} \right)$$

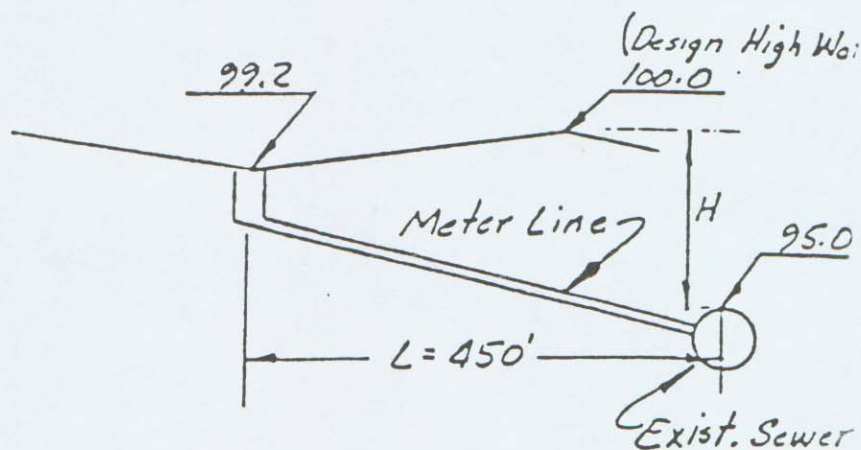
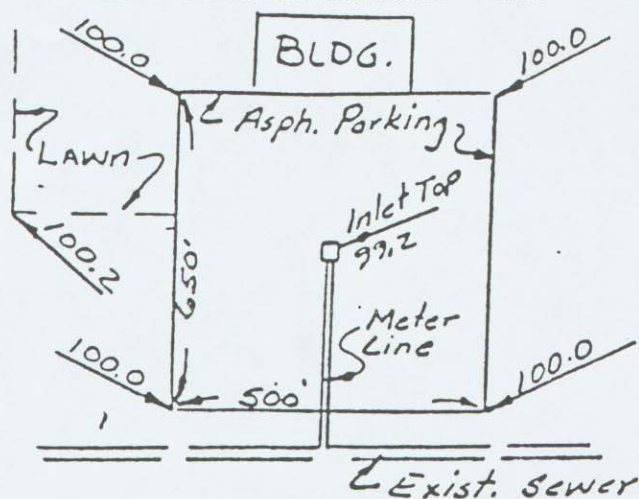
$$V^2 = \frac{2gH}{\left(1 + K_e + \frac{29n^2L}{R^{4/3}} \right)}$$

DATA:

1. Length of meter line = ft.
2. Slope of meter line = %
3. Size of meter line = in.
4. Pipe type & "N"
(CMP-n = 0.024 =
all others n = .013)
5. Entrance Coeff (K_e) = 0.5
6. Assumed Max. Head = ft.
7. Hydr. Radius (R) = ft.

(R 4/3) =

Assumed head(H)	H x 2g	$1 + K_e + \frac{29n^2L}{R^{4/3}}$	V^2	V	Area of Pipe (A)	Flow Q.	Q av. = $\Sigma Q./\text{number}$
0.5'							
1.0'							
1.5'							
2.0'							
2.5'							
3.0'							



Determine Weighted "C"

Gross Area = 578,000 ft²

Pavement Area = 325,000 ft²

Bldg. Area = 45,000 ft²

Lawn Area = 208,000 ft²

x 0.90 = 333,000

x 0.15 = 31,200

364,200

$C_w = \frac{364,200}{578,000}$

$C_w = 0.63$

Determine Allowable Q through Meter Line (Design Considerations "Sect. IV M".

$$Q_{allow} = C_i A = 0.15 \times 3.2 \times \frac{100 \times 500}{43,560} = 0.60 \text{ cfs.}$$

(100' depth x frontage)
 City of Toledo Method

Determine Detention Volume.

Lucas County

Use Total Acres
 C for soil type
 and i for time to outlet

t_c	i	CA	Q_{in}	Q_{out}	$(Q_{in} - Q_{out})$	$(Q_{in} - Q_{out}) \times t_c \times 60$
90	1.7	8.36	14.2	.6	13.6	$13.6 \times 90 \times 60 = 73,440 \text{ C.F.}$
120	1.4	8.36	11.7	.6	11.1	$11.1 \times 120 \times 60 = 79,920 \text{ C.F.}$
150	1.2	8.36	10.0	.6	9.4	$9.4 \times 150 \times 60 = 84,600 \text{ C.F.} \leftarrow \text{DESIGN}$
180	1.0	8.36	8.4	.6	7.8	$7.8 \times 180 \times 60 = 84,240 \text{ C.F.}$

Volume of Parking Lot. (Volume of Pyramid: $V = \frac{1}{3} L W \times \text{depth}$)

$$V = \frac{1}{3} (500' \times 650') (0.80') = 86,667 \text{ C.F.} > 84,600 \therefore \text{OK.}$$

Size of Meter Line - Use Eq. $V^2 = \frac{2gH}{(1 + K_c + \frac{29n^2L}{R^{4/3}})}$

$n = 0.013$; $R = 0.125 \text{ ft.}$
 $A = 0.196$; $R^{4/3} = 0.0625$
 $K_c = 0.5$; Size = 6"
 $L = 450'$

H	$H \times 2g$	$1 + K_c + \frac{29n^2L}{R^{4/3}}$	V^2	V	A	Q_1	$Q_{AV.}$
1.0	64.4	36.79	1.75	1.32	0.196	0.26	0.26
2.0	128.8	}	3.50	1.87	0.196	0.37	0.32
3.0	193.2		5.25	2.29	0.196	0.45	0.36
4.0	257.6		7.00	2.64	0.196	0.52	0.40
5.0	322.0	36.79	8.75	2.96	0.196	0.58	0.44

0.59 < 0.60 allowable - OK

-9- Use 6" Conc or PVC (n=0.013)

Corrugated (n=0.024)